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Seismology

6905 Body Waves
REGIONALIZATION OF CRUSTAL CODA Q IN THE CONTINENTAL UNITED STATES
Sudarshan Singh and Robert B. Herrmann (Department of Earth and Atmospheric Sciences, Saint Louis University, P. O. Box 8099, St. Louis, MO 63156)

A contour map of crustal Q_o values for the entire United States is presented based on a scattering model to explain the coda waves of local and near regional earthquakes. These coda Q_o values are in good agreement with Q of Lg waves. Data are obtained from over 250 local earthquakes, with most magnitudes between 3.0 and 5.0, recorded by 05 WWSSN and 27 LRSM stations throughout the continental United States. These two sets of data provide a range of frequencies from 0.5 to 3.5 Hz. A frequency dependence of Q is observed in the range of frequencies considered. A power law dependence of the form $Q = Q_o (f/f_o)^{\eta}$ is assumed. The value of frequency dependence η, is found to be maximum in the tectonically active western United States and least in the stable regions of the central and south central United States.

The lowest Q_o values are obtained in the western United States, with values ranging from 140 to 200 in the Coastal Plains. Average crustal Q_o values for the Basin and Range province vary from 200 to 300, increasing gradually to 400 in the Colorado Plateau region. Q_o values in the Columbia Plateau vary from 200 to 400. Q_o values increase very rapidly along the central and southern Rocky Mountains from 400 to 800. East of the Rocky Mountains Q_o values increase gradually to the Interior Plains to a maximum value of around 1300 in the Mississippi Embayment region. Farther east Q_o values decrease gradually to an almost constant value of 1000 along the Appalachian Mountains. Coastal regions of eastern and northeastern United States have a crustal Q_o value between 900 to 700. Regions of north central and Gulf Coastal Plains show low Q_o values, ranging from 600 to 400 and less.

The source factor $B(f_o)$, a measure of the intensity of scattering, was obtained for several different regions of the continental United States. Regions of high Q_o values exhibit low intensity of scattering.

J. Geophys. Res., Red, Paper 2B1739

6950 (Seismic Sources)
FOCAL DEPTHS OF INTRACONTINENTAL AND INTRAPLATE EARTHQUAKES AND THEIR IMPLICATIONS FOR THE THERMAL AND MECHANICAL PROPERTIES OF THE LITHOSPHERE
Wang-Ping Chen (Department of Geology, University of Illinois at Urbana-Champaign, 245 Natural History Building, 1301 W. Green Street, Urbana, IL, 61801), and Peter Molnar

We investigate the distribution of focal depths for earthquakes that do not appear to be associated with zones of recent subduction, using both new results from analyses of individual events recorded at teleseismic distances and published data for both microearthquakes and larger events. The deepest events in aseismic regions occur in old lithosphere (≥100 Ma)) and excluding earthquakes in active mountain belts, the deepest crustal events occur in old cratons (tectonic age ≥800 Ma). Therefore, the temperature at the source region is likely to be an important factor determining whether deformation occurs seismically or not. From estimates of the temperatures at depths of the deepest events, we conclude that those limiting temperatures are about 250 to 450°C and 600 to 800°C for crustal and mantle materials, respectively. In several regions of recent continental convergence, in addition to shallow crustal seismicity, there is seismic activity in the uppermost mantle. The lower crust, however, is essentially aseismic. We infer that both the upper crustal and the mantle seismic regions correspond to zones of relatively high strength, and that they are separated by a zone of lower strength in the lower crust where aseismic, ductile deformation predominates. This simple interpretation is qualitatively in agreement with extrapolated values of brittle and ductile strengths of geologic materials studied under appropriate pressure and temperature conditions in the laboratory. A low strength zone in the lower crust might allow detachment of crystalline nappes from the underlying mantle (and lower crustal) lithosphere. The apparently greater strength of mantle materials than crustal materials at the same temperature implies that oceanic lithosphere is much stronger than continental lithosphere, and this difference may account for why plate tectonics works well in oceanic regions but not in continents. (Focal depths, intraplate earthquakes, rheology of the lithosphere).

J. Geophys. Res., Red, Paper 2B1802

6970 Structure of the crust and upper mantle
THREE DIMENSIONAL CRUSTAL AND UPPER MANTLE STRUCTURE OF THE EURASIAN CONTINENT
C. C. Feng and T. L. Teng (Department of Geological Sciences, University of Southern California, Los Angeles, California 90089-0741)

Group velocities of fundamental-mode Rayleigh waves of 109 wavepaths within Eurasia have been measured by an improved frequency-time analysis technique. Stochastic inversion theory is applied to the mixed-path measurements to extract pure-path group velocities of 10° x 10° grid elements that form the subdivisions of Eurasia. Then, a three-dimensional crust and upper mantle structure of the Eurasian continent to a depth of 300 km is constructed.

The average crustal thickness of Eurasia is found to be about 40 km. Abnormally thick crust from 50 to 65 km is obtained in areas of Tien Shan, the Altai mountains, Afghanistan, Pamir, Tibet and Burma. Among them, Tibet has the least dense crust and highest elevation. This implies that at least part of the elevation of Tibet is due to isostatic compensation.

The upper mantle seismic velocity of the tectonically active regions of Asia is considerably lower than that of the European and Siberian cratons. If high velocity implies high rigidity, this explains that large-scale tectonic deformations of Asia occur in regions with weak upper mantle that deforms more plastically. Regions with stronger upper mantle remain relatively undeformed. This is especially evident for the tertiary tectonic deformation as a consequence of the collision of India with Eurasia.

J. Geophys. Res., Red, Paper 2B1677

6970 Structure of the crust and upper mantle
SEISMOTECTONICS OF SOUTHERN IRAN: THE OMAN LINE
Katharine Kadinsky-Cade (Department of Geological Sciences, Cornell University, Ithaca, New York, 14853)
Muawia Barazangi

Seismotectonic characteristics of the transition area between the Zagros continental collision zone and the Makran ocean-continent convergence zone (the 'Oman Line') are carefully examined. A northeast trending zone of earthquakes terminates the Zagros belt of seismicity just west of the Oman Line. This seismic zone extends northeastward beyond the Main Zagros Thrust and coincides with a surface escarpment clearly visible on LANDSAT imagery. Events with accurately determined depths along this seismic zone occurred in the upper 20 km of the crust and possibly show a shallow (<10°) northeastward dip. East of the Oman Line, the Zendan-Minab fault system is relatively aseismic. The Oman Line region may be characterized by underthrusting of a wedge of Arabian shelf edge beneath Iranian crust or by an indentation of Arabia into the Iranian crustal block as a promontory. Available seismological and geological data cannot uniquely distinguish between these two possible tectonic settings. The area located to the northwest of the Oman Line region, now a zone of continental collision, appears to have been characterized by an episode of Neogene subduction. A well-located, intermediate-depth earthquake occurred in this area to the northeast of the Main Zagros Thrust on November 9, 1970. It was accurately located at 107-km depth beneath a line of Quaternary volcanoes. Its focal mechanism may indicate downdip tension, with nodal planes that strike closely parallel to the trend of the Zagros arc. Comparison of this event and other neotectonic features in this part of Iran with those in other active convergent zones suggests that a descending oceanic lithosphere beneath the Zagros volcanic arc may still be attached to the colliding Arabian plate. (Tectonics, Southern Iran, Zagros, Oman Line).
Tectonics, Paper 2T1589

6975 Structure of the earth's interior below the upper mantle
A MODEL FOR THE FORMATION OF THE EARTH'S CORE
C.A. McCammon, A.E. Ringwood and I. Jackson (Research School of Earth Sciences, Australian National University Canberra A.C.T. 2600 Australia)

The recent discovery of a phase transformation in Fe_xO by Jeanloz and Ahrens has allowed a more detailed development of a model for core formation involving oxygen as the principal light alloying element in the core. It is predicted, based on calculations, that an increasing pressure in the system FeO-MgO will result in a gradual exsolution of an almost pure high-pressure phase FeO(hpp), leaving an iron-depleted (Fe,Mg)O component (Mw) phase. We also predict that FeO(hpp) will form a low-melting point alloy with Fe at high temperature and high pressure. On the basis of our interpretations, we have constructed a model for core segregation. Assuming the earth to have accreted from the primordial solar nebula as a relatively homogeneous mixture of metallic iron and silicate-oxide phases, core segregation involving oxygen would commence at a depth where pressure is sufficiently high to cause exsolution of FeO(hpp) from the residual phase, and temperature is sufficiently high to allow formation of an Fe-FeO(hpp) melt. A gravitational instability arises, leading to vertical differentiation of the earth as molten blobs of the metal sink downwards to form the core and the residual depleted silicate material coalesces to form large bodies which rise diapirically upwards to form the mantle. (FeO-MgO, core formation, high pressure, phase transformation)

J. Geophys. Res., Red, Paper 2B1641

News

Methane: Mantle Depths to Crust

A few years ago, Thomas Gold, Cornell's famous astronomer, entered the earth sciences by discovering, so he says, that methane gas is released from deep in the earth's mantle and is now trapped in large reservoirs within the crust. For a number of good reasons the idea has continued to bounce around the geological community for a while. The main attraction is that if Gold is correct, abundant energy sources can be tapped into the next millenium. Unless strong evidence is found to dispute his idea that most methane emissions from the crust are abiogenic, it seems wise to go on testing the concept. In spite of the tide in ridicule, 'Mantle methane—Fool's gold?,' of a recent article by the Planetary Sciences Unit (PSU) of the University of Cambridge, England (*Nature*, Nov. 25, 1982), it was determined that the idea of commercially exploitable accumulations of abiogenic methane should be checked out. In the words of the PSU, 'The possibility that primordial methane still outgases from the Earth, forms commercially exploitable accumulations, and is involved with higher hydrocarbon formation cannot be dismissed out of hand; constructive research and exploitation is necessary.'

There seem to be at least three methods to test Gold's ideas. One is the expensive, superdeep drilling program suggested to the United States Department of Energy by Gold and his supporters. Another is to analyze natural methane for its carbon isotope ratios to distinguish 'primordial' carbon-rich methane from the common biologically bound and produced type. A third approach is to examine the geochemistry of methane, analyzing its stability fields under deep mantle conditions to see whether it could survive. The first of these is too costly to attempt without more evidence. The second can be done, but so far the results are nonrommittal. The third could be done experimentally, but it would take time.

Meanwhile, Gold is stimulating further conjecture. For example, there is methane associated with ^3He, which is 'universally accepted as a primordial telluric gas component incorporated at the time of the earth's formation,' and methane has been observed in a Russian deep drill hole (*Nature*, op cit.). The methane from midocean ridges, volcanic areas, and tectonically active zones could be abiogenic, or it could be recycled, geologically old gas. If so, carbon-14 dating techniques cannot be employed. Stable carbon isotope ratios $^{13}C/^{12}C$ and hydrogen isotope ratios D/H could offer useful correlations, but the systematics are not well determined. For example, the ratios of stable carbon isotopes in natural diamonds vary excessively for unknown reasons. By the same token, there are precious few numbers of analyses available. What is known is that methane is a very stable form of carbon on the earth, in space, in the universe. Methane must have existed in the primordial earth; it exists now.—*PMB*

Mauna Loa Lauded

The American Meteorological Society (AMS) recently designated the Mauna Loa Observatory in Hawaii as the recipient of the AMS Special Award. Special awards are made to individuals or organizations not appropriately recognized by more specifically defined awards and who have made important contributions to the science or practice of meteorology or to AMS.

The Mauna Loa Observatory was cited for 'service to the scientific community for providing measurements of the chemical and physical background state of the atmosphere. The continuous records of CO_2 and atmospheric transmission, in particular, are internationally unique and specially important as basic information applicable to understanding climate variability.'

The observatory, constructed in 1956, began 2 years later to record CO_2 concentrations and atmospheric solar transmission. The CO_2 measurement record, obtained cooperatively with the Scripps Institution of Oceanography, is the best uninterrupted record of its kind. Other key measurements include precipitation chemistry, surface and total ozone, and atmospheric aerosol concentrations. Mauna Loa is a component of the Air Resources Laboratories, Environmental Research Laboratories, of the National Oceanic and Atmospheric Administration.

LANDSAT Support

A $5.3-million 1-year contract has been awarded to the Computer Sciences Corporation in Silver Spring, Md., to provide support services for operating the LANDSAT 4 satellite system, the National Oceanic and Atmospheric Administration (NOAA) recently announced. LANDSAT 4, launched in July by the National Aeronautics and Space Administration as part of a series of research satellites, helps to forecast crop yields, manage rangelands and forests, aid in the exploration for minerals and petroleum, assess water quality, gauge the effects of natural disasters, and plan land use.

The contract to Computer Sciences Corporation contains an additional 3-year option for a total of nearly $25 million over 4 years.

NOAA assumes responsibility for the satellite at the end of January.

OTA Congressional Fellowship

The Office of Technology Assessment (OTA) is seeking qualified candidates from academia, industry, and government for its Congressional Fellowship Program for 1983–1984. The program, similar to AGU's Congressional Fellowship Program, provides an opportunity for individuals who have demonstrated outstanding ability to gain a better understanding of science and technology issues facing Congress and the ways in which Congress establishes national policy related to these issues.

OTA will select up to six fellows for a 1-year stint, which begins in September 1983, on Capitol Hill. The program is open to men and women of all disciplines who have demonstrated exceptional competency in the physical or biological sciences, engineering, law, economics, environmental and social sciences, or public policy. Candidates must have completed research and training at the doctoral level or have equivalent experience, as judged by the OTA fellowship selection committee. Salaries for successful candidates will range from $24,000 to $38,000 per year, based on the fellow's current salary and/or training and experience.

Fellowship applicants are required to submit a resume (up to two pages) that lists education, experience, area(s) of special interest; a one-page list of published works; three letters of reference; and a statement of roughly 1000 words addressing the applicant's principal expectations of the fellowship program and his/her expected contributions to OTA during the program. For additional information, write to Congressional Fellowships, Personnel Office, Office of Technology Assessment, Congress of the United States, Washington, DC 20510. Applications for the fellowship and letters of reference should be sent to the above address no later than February 11, 1983. The letters of recommendation should be sent directly to OTA.

Books

Land and Stream Salinity

J. W. Holmes and T. Talsma (eds.), *Dev. in Agr. Eng.*, vol. 2, Elsevier, New York, 392 pp., 1981, $80.50.

Reviewed by Mohamed T. El-Ashry

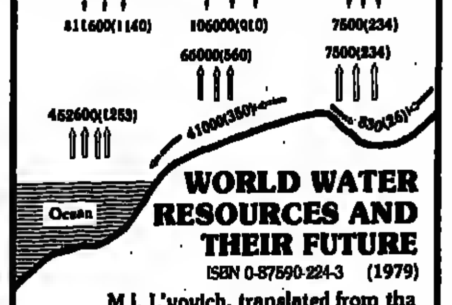
Soil salinity and salinity in water supplies are two major problems facing agricultural production in many arid and semi-arid regions of the world. Salt, in varying concentrations, occurs naturally in both soils and aquifers. However, salinity problems usually result from man's interference with natural processes and disturbance of the hydrologic balance. For example, the clearing of trees in southwestern Australia and the breaking of native sod in the Great Plains of North America for wheat cropping have reduced evapotranspiration. At the same time, over irrigation in dry regions concentrates dissolved salts in the soil profile, while irrigation return flows add to downstream salinity problems. These problems are of great economic significance, and opportunities are being sought for improved drainage and for interception and disposal of saline groundwater. However, these structural solutions are capital-intensive and quite expensive to say the least. The most cost-effective measures, but also the most challenging, are in the areas of improved on-farm water management to reduce losses, modified cropping patterns, selected retirement of marginally productive lands, and basin-wide water resource management with regard to both quantity and quality objectives.

This volume is a reasonable contribution to the understanding of the problem of land and stream salinity and of control efforts, with major emphasis on dryland salinity and little emphasis on irrigated lands. It contains 19 papers presented in an international seminar and workshop held in November 1980, in Perth, western Australia. The objectives of the workshop, as stated in the introductory section, were (1) to review the state of knowledge of processes involved in land and stream salinity and to consider its application in different environments; (2) to identify gaps in research and development and to designate priorities for salinity control; (3) to identify alternative land and water management strategies for salinity control; and (4) to give a degree of emphasis in the above objectives to salinity problems in southwestern Australia. The last objective was well met with 11 of the 19 papers dealing with salinity issues in Australia while six papers dealt with problems in the United States, one with the Netherlands, and one with Israel.

The papers discuss six broad topics: causes of dryland salinity (two papers), transport of salt through the soil (four papers), groundwater systems (four papers), prediction of stream and reservoir salinity (four papers), soil and plant management (two papers), and land water management (three papers). The quality of the papers vary from sophisticated and sound models based on actual field measurements, to mathematical speculation, to papers which seem almost contrived to fit the occasion of the workshop.

The volume underlines the need for solutions to salinity problems in the recharge areas, as opposed to the discharge or saline discharge areas. Besides their cost effectiveness, such solutions would also result in water conservation. However, it is also indicated that customary engineering solutions such as shallow and deep drainage to remove saline water should not be rejected and that the disposal of the saline water must be considered carefully. In this regard, the U.S. Bureau of Reclamation is considering the use of highly saline water from the Upper Colorado River Basin in coal slurry pipelines as well as for other energy-related uses.

Mohomed T. El-Ashry is with the Office of Natural Resources, Tennessee Volley Authority, Knoxville, Tenn.



Transition and Turbulence

R. E. Meyer (ed.), *Math Res. Center Symp. and Adv. Semin. Ser.*, Academic, New York, ix + 245 pp., 1981, $15.50.

Reviewed by S. A. Thorpe

Naturally occurring fluid flows are seldom in a state of fully developed turbulence, except near boundaries. The upper atmosphere and the ocean, in and below the thermocline, are dominated by wave-like motions. Turbulence when, and where, it occurs is sporadic and short-lived; it is transitional rather than maintained. The subject of this volume is thus of importance and relevance to scientists concerned with understanding the motion and mechanics of 'geophysical' fluids.

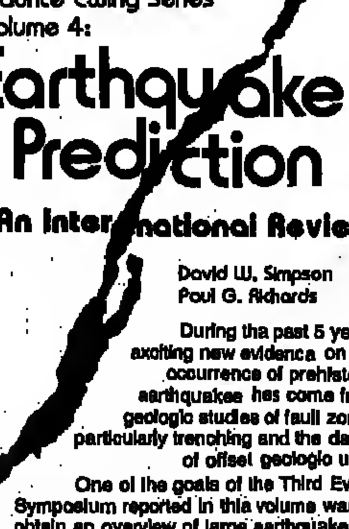
This volume contains 12 (sadly not all) of the invited lectures at a symposium held at the University of Wisconsin in October 1980. Many of the distinguished authors offer very forthright and refreshingly clear commentaries on the state of the art and, in particular, on the areas where perspectives differ.

There are two major themes. First, there is the concept of successive stages, reached by bifurcations, through which a flow passes en route from a laminar to a turbulent state. DiPrima and Benjamin describe those in flow between rotating cylinders (Couette flow, steady Taylor vortex flow, periodic wavy vortex flow, quasi periodic wavy vortex flow, chaotic flow) while Busse discusses those in thermal convection (no motion, convection rolls, bimodel convection, oscillating bimodel convection, spoke pattern convection and chaotic motion). Spectral methods are now widely used to describe the flows. After half a century of investigation, the theory of steady flows (those that follow the first bifurcation) seems reasonably secure, but that of unsteady flows is yet rudimentary; turbulence is yet some way ahead.

The second theme is that of coherent structures. Awareness of organised patterns in turbulence dates back nearly 3 decades to the 'large eddy' concepts of Townsend, and is perhaps germane to the ideas of Malkus and others of marginal stability of turbulent flows. Attention has been drawn to these features by laboratory work, notably Brown and Roshko's experiments, and this has encouraged the recognition that measurement of statistical quantities alone provides at best only a partial understanding of turbulent flows dynamics. The question of whether or not these structures, which resemble those found at the onset of instability, are truly inherent in fully developed turbulence or are simply a remnant of a transitional instability, is perhaps now academic. What is clear is that, as Laufar puts it, 'the initial instability of the flow can have a surprisingly strong influence on its subsequent development; thus, the instability and the subsequent turbulent state of the flows are coupled.'

The text is lightened by several entertaining remarks. Vorticity, says Saffman, is the 'sinews and muscles of fluid motion.' Lumley, critical of conditional sampling which reveals structures, likens them to 'the birds in an Escher woodcut, that are formed by the spaces between other birds.' He 'cannot call them non-existent, since they are there, but they are formed by chance juxtaposition of other, relevant, structures, and have no significance.' It seems to me a pity that the volume is so poorly finished. The reviews deserve better presentation than that of typewritten pages with their numerous typographical errors and crude figures. There is a short index, and each review includes its own list of references. Perhaps the fairly low price, making this excellent account of recent developments available to many readers (and graduate students will find much of great value), justifies the poor quality

S. A. Thorpe is with the Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, U.K.



Forum

Toward a United States Arctic Research Policy

Status of Arctic Research Coordination

Of all countries bordering on the Arctic, the United States is the only one without a national institute, laboratory, or any other organization devoted to the sustained planning and support of Arctic research. Up to now, the responsibility for planning, implementing, and funding Arctic research has been divided between several federal agencies, the state of Alaska, and private groups whose mandates or objectives are often unconnected.

The result of this pluralistic approach to U.S. science in the Arctic is that basic research has been conducted in piecemeal fashion. Individual studies are proposed and supported separately, and their costly logistic requirements must be funded in competition with research carried out under less-demanding environmental conditions in the rest of the country. Fundamental data-gathering and interpretation of information has been the responsibility of public agencies whose missions are separate and whose budgets may not reflect the priorities of Arctic issues.

Applied research has often been proprietary; as industrial research became dominant in volume and continuity, much scientific information and understanding of Arctic processes moved out of the public domain. Development often preceded the acquisition of necessary scientific knowledge; indeed, scientific research in the Arctic has frequently been supported as a corrective measure only after the need for such knowledge was made apparent by serious mistakes or problems.

A boom/bust development characterized most U.S. Arctic research, as scientific thrusts, often short-term and unrelated, followed one another. Because of the lack of continuity in science support, teams that achieved scientific advances disintegrated after completion of their missions, often without complete documentation of their work. At later dates, whole new groups had to be formed to resume studies on the same subject. Long-term research has been losing progressively to short-term crash studies.

This state of affairs is in sharp contrast with Arctic research and Arctic science policies of most other circumpolar nations. The Soviet Union, for instance, has clearly defined goals toward which their Arctic policy and related research thrusts are oriented; an estimated 20–25 thousand scientists work on Arctic research there; no less than 170 scientific institutes are involved in research linked to offshore oil and gas exploration and exploitation alone; 37 Arctic research vessels and 19 icebreakers are available; and vast numbers of institutes and specialized technical and vocational schools develop human expertise in a concerted effort to achieve the Soviet Arctic policy goals.

In the past there have been several high-level attempts to coordinate U.S. Arctic research programs. For instance, the Interagency Arctic Research Coordinating Committee (IARCC) was established in 1967 and given a number of specific tasks. A few years later the expectation of an accelerated pace of activities in the U.S. Arctic led to several U.S. policy decisions. In particular, National Security Decision Memorandum (NSDM) 144 of December 21, 1971, established as national policy '. . . that the U.S. will support the sound and rational development of the Arctic, guided by the principle of minimizing any adverse effects to the environment; will promote mutually beneficial international cooperation in the Arctic; and will, at the same time, provide for the protection of essential security interests in the Arctic. . . .'

Unfortunately, mechanisms for funding and for the adequate implementation of these policy decisions were not developed concomitantly. In 1978 the President's science adviser informed the pertinent agencies of the formal dissolution of IARCC. A recent study conducted by the *Departments of Interior, Defense, and Energy* [1982] came to the conclusion that '. . . the intentions of NSDM 144 have never been implemented and the U.S. lacks an explicit arctic research policy.'

Difficulties in the Establishment of a National Arctic Research Policy

Several factors contributed to the difficulties in establishing a U.S. national research policy for the Arctic:

Alaskan, national, and international interests. Alaska is the only U.S. state in arctic and subarctic territory. An Arctic research policy is thus viewed by many as a research policy for Alaska, a 'bonanza' for Alaskan scientists. At the federal level, many of the scientific and technological problems are perceived as being of predominantly 'Alaskan interest,' consequently, they are expected to be funded mostly from Alaskan sources. In turn the Alaska state government is reluctant to support specific Arctic research programs whose intended beneficiaries are spread over the entire nation. To counter these arguments, one must point out that the resource development in the United States arctic and subarctic regions and adjacent waters and the deployment of defense systems at high latitude have become, and will remain, a vital part of our entire nation's economy, trade, and security. And one must point out that U.S. interests in the Arctic extend far beyond the boundaries of U.S. territory, waters, and air space. The United States has vital defense interests in the entire Arctic Ocean, Northern Canada, and Greenland. It has extensive scientific research interests in Northern Canada, Greenland, and Svalbard and vital interests in the international economic and cultural policy issues common to all circumpolar nations and their native people.

The definition of 'Arctic.' Another complicating factor is the very definition of the concept 'Arctic' in the context of a U.S. Arctic policy. The Arctic is normally thought of as a geographical region, one that can be defined by geographic coordinates. In the context of human activity, technology, and science, however, the concept of 'Arctic' is much broader and should be defined in an operational way. Indeed, when we talk of 'Arctic policy,' we think of it as applied to, or related to, those high northern latitude regions in which cold climate, long winter nights, sea ice, permafrost, ice fog, scarcity of fast surface transportation routes, and geomagnetic and auroral perturbations are all factors that, individually or in concert, impair the transplantation of 'conventional' lifestyles and technologies from lower latitudes.

Facts, figures, and for instances. A third factor complicating the establishment of a national Arctic research policy is related to the difficulty of estimating the (substantial) cost of not having one. Frequently, politicians, the lay public, and scientists unfamiliar with Arctic research, ask for 'facts and figures' about the uncoordinated, piecemeal, boom/bust Arctic research endeavors and the related waste of financial and intellectual resources. This is most difficult to provide, mainly because the really significant examples are not easy-to-appraise blockbuster 'blunders,' but, rather, the myriad of incidents which, taken together, present a macroscopic configuration whose impact is painfully evident to those who actually perform Arctic research but quite laborious to describe to others. A good account of examples of individual incidents is given in *Hickok et al.* [1981].

The multiplicity and interdisciplinary nature of scientific goals. The sheer number of Arctic research problems that await solution is staggering. In the geosciences alone we may cite as examples of broad Arctic research goals: (1) acquisition of an adequate data base of key geophysical parameters needed in long-term environmental forecasting; (2) study of global atmospheric circulation in the Arctic, circumpolar distribution of industrial pollutants, and related potential climate impact; (3) study of sea-ice mechanics; (4) sea-ice forecasting; (5) study of pollutant dispersion in ice-bearing soils and ice-infested waters; (6) prediction of polar upper-atmosphere disturbances and effects on northern communications and defense systems; (7) permafrost dynamics, detection, and mitigation of effects on structures; (8) ice-fog dynamics and potential mitigation. To this one must add less site-specific topics but ones of great site-specific importance, such as the geology and tectonics of the Aleutian Chain, the Alaskan North Slope, the Arctic Ocean Basin, etc. Similarly, extensive lists can be drawn for all other major scientific disciplines. Quite generally, Arctic science is eminently interdisciplinary in nature—Arctic phenomena and processes cannot be studied in isolation, Arctic studies are very expensive, and the need for coordination is dictated more by logistic considerations than by strictly scientific arguments.

The military-industrial complication. Finally, another complicating factor for Arctic research policy arises from the restricted dissemination of information on research carried out by two crucial 'users' of the Arctic: private industry and the military. The private sector has been reluctant to invest large sums in developing local technologies and solving local problems and, then, sharing the results with other competing enterprises in the north. This picture is compounded by an understandable suspicion on the part of industry that national coordination or national policy setting could lead to greater control and regulation. Yet, by and large, industry would be a prime beneficiary of an expanded and more reliable public data base on the arctic environment and arctic processes and of better and faster conduits to greatly expanded sources of scientific information. On the military side, the Department of Defense is reluctant to tie its Arctic research needs to a public Arctic science policy. Such a policy cannot explicitly address nor include Department of Defense research, but it can help create a research environment conducive to providing the Department of Defense with crucial information, environmental data, basic research results, and above all, the expert manpower needed to answer myriad relevant technical questions.

Elements of a National Arctic Research Policy

One of the most difficult tasks in developing a national Arctic research policy is to provide for a fair balance between inherently antagonistic interests, such as the thrust for profit-guided development and decreased governmental regulation of industry, the concerns for adequate and long-term environmental and cultural protection of the native people, the concerns for national defense and related protection of information of the military, and the concern for objective, unbiased, and open research of the academic community.

A national policy for Arctic research should take into account the following important factors, which will bear on, or determine, national decisions concerning the Arctic:

1. *The natural resource potential of the Arctic during a time of intense global competition for resources.* It is estimated that as much as 50% of the total undiscovered oil resources remaining within the jurisdiction of the United States occur in the Arctic [*National Petroleum Council*, 1981]. The U.S. Arctic also contains immense reserves of coal as well as strategic minerals and an extremely valuable marine fishery.

2. *The susceptibility of the Arctic environment to man-caused change.* Many aspects of the Arctic land, freshwater, and marine ecosystems are vulnerable to environmental changes; recovery rates are slow, and some effects can be expected to be long-term. Many of the observations and studies that would assist long-term planning and the minimization of undesirable effects of human activities in the Arctic are not yet available.

3. *The effects of technological and developmental changes on the lifestyles, values, and culture of the native population of the Alaskan Arctic.* Alaska is clearly in a difficult period of transition. Although native groups realize that more changes are inevitable, they wish to thoroughly understand the many ramifications of proposed developmental decisions so that they can achieve a balance of economic and cultural well-being.

4. *The strategic location of the Arctic.* A thorough understanding of the Arctic environment is essential to an effective North American defense posture. Of particular importance are all aspects related to frozen ground, arctic climate, sea ice and the Arctic Ocean, and the upper atmosphere and ionosphere at high geomagnetic latitudes.

5. *The need and opportunities for international cooperation and exchange of information.* Much Arctic research involves the ocean, the atmosphere, and the biological populations—entities that do not conform to national boundaries. Thus it is important to have effective exchange of technical information between Arctic nations and to expand the circle of cooperating nations. Yet the Arctic is one notable area untouched by existing or prospective international agreements [*Bloomfield*, 1981].

The implementation of a national Arctic research policy will require an Arctic research plan for the next 10 to 20 years. It should be the purpose of such a plan to accomplish the following tasks:

1. Identify and assign priorities to Arctic research needs and opportunities in the physical, biological, and social sciences that deserve special national attention.

2. Provide a long-term commitment to Arctic research by assigning organizational responsibility for the coordination, management, and funding of a program designed to meet identified high-priority research needs.

3. Identify the relative roles in Arctic research of the federal, state, local, private, and university sectors, and provide a basis for their involvement in the design and conduct of an Arctic research plan.

4. Provide for mechanisms and institutional arrangements to obtain an adequate data base concurrently with research on fundamental Arctic processes; this would go far toward improving the prediction of long-term environmental changes associated with Arctic resource development.

5. Promote a concerted effort to obtain quantitative understanding of short-term natural and anthropogenic hazards and risks in the Arctic, and improve prediction and prevention capabilities.

6. Provide a clearinghouse mechanism for the timely dissemination of major results and conclusions of public research, nonproprietary private research, and unclassified military research; as well as information on related manpower, facilities, and equipment.

7. Provide continuity and stability to Arctic research so that young scientists will enter and remain in professional careers in Arctic investigations, thereby providing a cadre of trained and experienced specialists.

8. Stimulate a nationally integrated means for evaluating laboratory and logistics requirements for the conduct of Arctic research.

9. Stimulate international cooperation in the solution of problems of common interest to northern circumpolar nations.

Although the principal requirement in the implementation of Arctic research policy will be a carefully planned coordination of research and information exchange among participating organizations, there is a need for additional funding in three aspects: (1) to subsidize the high costs of logistics so that interested research organizations, both public and private, can participate in an Arctic research plan without having to augment the budgets of their research proposals with intolerably high logistics costs and thus jeopardize their competitiveness in the national research market; (Note that for research in Antarctica, logistics costs are not included in individual proposals!) (2) to support the establishment and maintenance of temporary or permanent field stations in the Arctic; to support ice-strengthened vessels and icebreakers; to support data and information centers, etc.; (3) to support selected research projects not explicitly included in the missions of existing federal or state funding agencies.

Current Developments

The Polar Research Board [1982] of the National Academy of Sciences established a Committee on Arctic Research Policy, which has produced a report entitled *A United States Commitment to Arctic Research*. In this report it is recommended that the United States government include a commitment to the support of scientific research in its Arctic territory and in other areas of Arctic interest as a necessary and integral part of its national policies for economic, technical, and social development, resource development, environmental protection, national security, and international cooperation in the Arctic. It is further recommended that to assure productive polar research the United States government improve the coordination and effectiveness of federal Arctic research programs and provide stability and continuity of effort.

In parallel with the preparation of the above Academy report, Senator Frank Murkowski (R., Alaska) introduced a bill, cosponsored by Senators Ted Stevens (R., Alaska), Slade Gorton (R., Wash.), and Henry Jackson (D., Wash.), entitled the Arctic Research and Policy Act of 1982. This bill has been passed unanimously by the Senate Committee on Governmental Affairs and was approved by the Senate on December 10. The bill provides for the establishment of an Arctic Science Policy Council, whose purpose would be to facilitate cooperation between the federal government and state governments with respect to Arctic research, to develop and supervise an Arctic science policy, and to coordinate and promote international research programs. The bill further establishes an Arctic Research Commission, whose duties would be to survey Arctic research and make recommendations to the Council on priorities for future research, to establish a data collection and retrieval center, and to make grants for Arctic research, with special consideration of neglected areas. Finally, an Arctic Research Fund of $25 million is established in the form of a trust fund that would consist of federally appropriated monies and amounts contributed by the state of Alaska and private individuals or organizations.

Juan G. Roederer
Geophysical Institute
University of Alaska, Fairbanks

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For further information or to place an ad call toll free 800-424-2488 or 462-6903 in the Washington, D.C. area.

POSITIONS AVAILABLE

Isotope Geologist/University of Wyoming. The Department of Geology/Geophysics invites applications for a tenure track position at the assistant professor level in isotope geology. The applicant's field of specialty may be stable or radiogenic isotopes. The successful candidate will be expected to teach undergraduate and graduate courses and conduct his/her own research program.

Current research at the University of Wyoming includes: crustal evolution in the Archean and Proterozoic; the systematics of magma contamination; carbonate diagenesis; fluid-rock interaction; and the tectonic evolution of compressional and extensional orogenic belts. We hope the successful candidate will complement these studies as well as develop a strong, independent program. Applicants should submit a vita, transcripts, a letter describing future research interests, and names of three references to Dr. Robert S. Houston, Head, Dept. of Geology/Geophysics, PO Box 3006, University Station, University of Wyoming, Laramie, WY 82071. Closing date for applications is February 28, 1983.

The University of Wyoming is an equal opportunity/affirmative action employer.

Research Investigator (Postdoctoral Research Associate). This position requires a Ph.D. in magnetospheric physics; experience in both theoretical and observational plasma physics; and experience in data reduction and analysis of satellite data from plasma analyzers and VLF plasma wave instruments. Salary $19,800 per year ($1,650 per month). Submit resumes to: Job Service of Iowa, 1810 Muscatine Avenue, Iowa City, Iowa 52240, Job order number 1344652, Attention: Dave Siebel.

EOS

Transactions, American Geophysical Union

Send double-spaced manuscripts (four copies) to *Eos*, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above address.

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Cover. View west toward the Deadman Creek rhyolite dome of the Inyo chain of vents. C. Dan Miller, USGS, has obtained the youngest date in the region, 200 radiocarbon years, from charcoal in a pyroclastic flow associated with this vent. *Hill* [1976] found an anomalous seismic reflector, possibly the top of a magma body, at 7 km beneath this area. The west wall of Long Valley caldera is the steep dark slope behind the dome (see 'Continental . . .,' p. 12, for more information). (Photo supplied by Rundle and Eichelberger.)

The Ohio State University/Graduate Fellowships. The Department of Geology and Mineralogy invites applications from outstanding students with strong research interests who wish to study for the Ph.D. and M.S. degree. Applicants will compete for full-time Research Fellowships, including the Shell Doctoral Fellowship, and AMOCO, Atlantic Richfield, J. A. Bownocker, W. J. McCaughey, J. E. Carman, W.W.&L. Castor and University Graduate Fellowships. The awards provide stipends for 9 to 12 months and cover in-state or out-of-state tuition and fees. Additional financial support is available to cover field and laboratory expenses and conference travel.

Potential study and research areas include (but are not necessarily confined to) regional geology, stratigraphy, sedimentology, micro- and macro-paleontology, isotope geochemistry, igneous and metamorphic petrology, geophysics, economic geology, Quaternary geology, and glaciology. Successful applicants will have opportunities for laboratory research and field work in the United States and abroad, including the polar regions.

For details of the graduate studies program, admission materials and further information on the Department of Geology and Mineralogy contact Dr. Kenneth Foland, Chairman, Graduate Studies Program, Department of Geology and Mineralogy, The Ohio State University, Mendenhall 107, Columbus, Ohio 43210 (or phone: 614-422-2721).

Completed applications must be received by February 1, 1983 for awards commencing in September 1983. Outstanding applicants may be invited to visit The Ohio State University in early 1983.

Postdoctoral Positions in Planetary Studies. The Laboratory for Atmospheric and Space Physics at the University of Colorado has openings for two postdoctoral appointments. One appointment will be for study of Voyager observations of planetary rings. The other appointment will be in the field of planetary atmospheres: aeronomy, radiative transfer, and cloud chemistry and microphysics. The Laboratory for Atmospheric and Space Physics is involved with the acquisition, analysis, and understanding of spacecraft observations of solar system objects. Current active missions include Voyager, Pioneer Venus, and Galileo. Applications are invited from graduating students and recent graduates with experience in one or more of the above areas. The term of appointment is for one year with possible renewal on a yearly basis; the starting salary is approximately $1900 per month.

Send letter of application, resume and names of two references by April 15, 1983 to:

Prof. C. A. Barth
Laboratory for Atmospheric and
Space Physics
Campus Box 392
University of Colorado
Boulder, CO 80309

The University of Colorado is an equal opportunity/affirmative action employer.

Iowa State University of Science and Technology, Department of Earth Sciences/Faculty Positions. Applications are invited for a tenure-track faculty position in mineral resources. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program in mineral resources/economic geology and will teach undergraduate and graduate courses in this subject. An applied field orientation is preferred.

Iowa State has established a Mining and Mineral Resources Research Institute in order to support and develop research and education in mineral resources. An interdepartmental graduate minor in Mineral Resources has also been established. In addition to the appointment in the Department of Earth Sciences, there will be full opportunities to interact with these programs.

Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral or industrial experience will be an advantage. The position is currently available and is expected to begin no later than September 1983. For application information, please write to:

Bert E. Nordlie, Chairman
Department of Earth Sciences
253 Science I
Iowa State University
Ames, Iowa 50011

Iowa State University is an equal opportunity affirmative action employer.

Exploration Geophysicists. Montana College of Mineral Science and Technology announces two tenure track faculty positions for Exploration Geophysicists in the Department of Physics and Geophysical Engineering starting August, 1983. Duties include teaching advanced undergraduate and graduate courses in geophysics and supervising thesis students (M.S. Geophysical Engineering). Ph.D. required. Preference will be given to the applicants with experience in electrical exploration and/or potential field methods. Research is expected. Salary and rank commensurate with experience. Send resume, letter of application, copies of graduate transcripts and names of three references to Vice President for Academic Affairs, Montana Tech, Butte, MT 59701.

An equal opportunity/affirmative action employer.

Faculty Position/Princeton University Department of Geological and Geophysical Sciences. We are looking for an exceptionally creative individual in the general area of paleontology—stratigraphy—sedimentology for tenure-track appointment as Assistant Professor. Rapid increases in understanding of the processes and history of the earth's surficial environment have come about through analytical and theoretical advances in many specialities, such as magnetic stratigraphy, clay mineralogy and geochemistry, seismic stratigraphy, isotopic and microanalytical studies of fossils and sediments, sedimentation related to crustal tectonics, and mathematical analysis of stratigraphic and paleontological data. We seek candidates with strong interdisciplinary research interests in areas such as those listed, with the analytical skills and foresight to work effectively on the frontier. Within the department, the appointee should be able to take responsibility for an area such as stratigraphy, paleontology, or sedimentology, and provide a broad historical perspective. We plan to back up this appointment by our program for a general expansion of laboratory facilities, as appropriate.

Inquiries should be made to: R. A. Phinney, chairman, at the above address, or by phone, (609) 452-4100. While later applications will be considered, we would like to have them by the 31st of January, 1983, or earlier, if possible. Applicants should submit: resume, names of at least three references, and a statement of research plans and priorities.

Princeton University is an equal opportunity affirmative action employer.

Research Faculty Positions in Oceanography/University of Southern California. Applications are invited for three research faculty positions. Individuals with established records of excellence in sea-going research programs in biological, geological, chemical and physical oceanography are sought. At least one appointment each in geological and biological oceanography is planned. Individuals applying should have coastal oceanography as their major geographical area of interest. Special attention would be given to applications from interdisciplinary teams, e.g., in benthic boundary layer studies, interaction of plankton and circulation, chemical/biological transformations, etc. These positions carry a commitment of up to 50% of salary from USC sources. Appointments are expected to be made by July 1, 1983. Contact:

Dr. Richard Dugdale, Director
Allan Hancock Foundation
University of Southern California
Los Angeles, CA 90089-0372

or

Dr. Robert Douglas, Chairman
Department of Geological Sciences
University of Southern California
Los Angeles, CA 90089-0741

USC is an equal opportunity/affirmative action employer.

Economic Geologist/Washington State University. Washington State University seeks applicants with interests in the genesis, geochemistry, and field relations of mineral deposits for an anticipated tenure-track position at the assistant professor level beginning September 1983.

Washington State University is located in the Pacific Northwest in a region of abundant mineral deposits. The geology department is young, growing, and has excellent facilities for geologic research, including a new, fully-automated electron microprobe/SEM.

The successful applicant should have the Ph.D., have a sincere commitment to research, be a competent field geologist, and be able to teach introductory courses as well as courses in his/her specialty. Industry experience and an interest in sedimentary ore deposits are desirable.

To apply, send a statement of teaching and research interests, resume, and the names of four references by February 1, 1983 to:

Dr. Lawrence D. Meinert
Geology Department
Washington State University
Pullman, WA 99164-2812

Washington State University is an equal opportunity employer.

Faculty Position/Environmental Engineering, University of Virginia. Biological and chemical processes in water quality control systems and in natural waters, beginning September 1, 1983. The position requires undergraduate and graduate teaching and sponsored research activities. An earned doctorate is required and at least one degree in civil engineering is preferred. Industrial or consulting experience is desirable. Rank will be at the assistant professor level and salary will depend upon qualifications. Apply to: Dr. Lester A. Hoel, Chairman, Department of Civil Engineering, University of Virginia, Charlottesville, Virginia 22901. Deadline for receiving applications is February 15, 1983.

An Affirmative Action/Equal Opportunity Employer

Texas A&M University/Faculty Positions. The Department of Geology invites applications for several tenure-track faculty positions effective September 1983. Preferred specialties are in:

1. *Engineering Geology;*
2. *Clay Mineralogy* with emphasis on sedimentation, geochemistry, and diagenesis;
3. *Stratigraphy* with emphasis on the relationship of sedimentation and stratigraphy to structural setting and style; and
4. *Structural Geology* with emphasis on theoretical, experimental, petrofabric or field studies, such as to complement the ongoing nine-man effort in the Center for Tectonophysics.

The Department offers programs leading to B.S., M.S., and Ph.D. degrees in Geology. The department is in the College of Geosciences, with strong interactions with separate departments of Geophysics and Oceanography.

Qualified persons should submit a resume, names of 3 references, and a statement of research interests to Robert J. Stanton, Head, Department of Geology, Texas A&M University, College Station, Texas 77843.

Texas A&M University is an equal-opportunity affirmative-action employer.

Faculty Position/Bryn Mawr College. One year, junior level appointment for '83–84. Teaching responsibilities: four one-semester courses, including undergraduate structural geology and graduate seminar. Additional expertise in stratigraphy, sedimentology or oceanography preferred; strong background in computer applications in geology desired. Candidates must have completed all Ph.D. requirements. Send letter of application, resume and transcripts to:

M. L. Crawford, Department of Geology
Bryn Mawr College
Bryn Mawr, PA 19010.

Bryn Mawr College is an equal opportunity employer.

Atmospheric Scientists/Scientific Programmers. Applied Research Corporation has immediate openings (2 positions) in the analysis of stratospheric ozone, temperature, and minor constituent satellite data. Requires extensive experience in the handling of atmospheric and meteorology satellite data. For one position, familiarity with stratospheric chemistry is required. For the other position, an atmospheric dynamicist is required to use this data for numerical modeling purposes. Computer experience on VAX 11/780 and Cyber 203 or other vector machines is desirable.

Candidates must have M.S. or Ph.D. degrees in atmospheric science or meteorology. These positions support science and applications tasks at NASA/Goddard Space Flight Center, Greenbelt, Maryland, and require on-site work.

The salary range is open depending on qualifications. Applied Research Corporation offers excellent benefits. Initial appointments will be for one year (renewable up to 3 years).

Qualified applicants should send their resume, names of three professional references, and salary history to:

Dr. S. P. S. Anand
Applied Research Corporation
8201 Corporate Drive, Suite 920
Department EOS-11
Landover, Maryland 20785.

THEORETICAL OR EXPERIMENTAL SPACE PLASMA PHYSICISTS

NASA-MARSHALL SPACE FLIGHT CENTER
Huntsville, Alabama 35812

Two positions in theoretical or experimental space plasma physics are available in the Magnetospheric Physics Branch of the Space Science Laboratory at NASA's Marshall Space Flight Center. Either theoretical or experimental backgrounds will be considered with a preference given to theoretically oriented researchers to complement the extensive experimental activities of the branch. The Magnetospheric Physics Branch is involved in the analysis of low-energy plasma data from the ISEE, SCATHA, and Dynamics Explorer satellites, from sounding rockets, and from the Space Shuttle (STS-3). In addition, the group is presently carrying out the joint development of a variety of active space plasma experiments that will be flown on Spacelab One, Two, and Six.

Salaries range from $34,930 to $41,277 per annum, depending on experience.

Interested applicants may contact Dr. Charles R. Chappell at the Marshall Space Flight Center (205-453-3036). Forward resumes to the following address not later than March 1, 1983:

NASA-Marshall Space Flight Center
Space Science Laboratory
Attn: Dr. Charles R. Chappell, ES51-R2
Huntsville, AL 35812

NASA

An Equal Opportunity Employer — U.S. Citizenship Required

Department Head/Texas A&M University. The Department of Geology is engaged in a nationwide search for a new Department Head with the anticipated starting date being September 1, 1983. The position is open as to salary, rank and area of interest. We are seeking a person with a national or international reputation in the geological sciences who would take over the leadership of our research and teaching oriented department.

Our faculty currently numbers twenty three and will increase by three by the Fall of 1983. Construction started in January, 1983 on a 60,000 square foot addition to the Halbouty Geosciences Building. We currently have an undergraduate enrollment of over 400 students and there are about 130 students in our graduate (M.S. and Ph.D.) program. The Department of Geology is in the College of Geosciences (Dean Gordon P. Eaton) along with the Departments of Geophysics, Oceanography, Meteorology and Geography. The traditional strengths of the department are in the areas of stratigraphy, sedimentation, paleontology, structure-tectonophysics and engineering geosciences. Our strong ties with industry are reflected in the level of financial support and jobs for our students. If you would like to be considered for this position, please submit a recent resume along with the names of at least three persons who are willing to write letters of recommendation. Send Applications To:

John H. Spang
Chairman, Search Committee
Department of Geology
Texas A&M University
College Station, Texas 77843.

Texas A&M is an equal-opportunity affirmative-action employer.

Faculty Positions/University of Washington, Department of Geological Sciences. *Position 1.* The department seeks a *geologist* with demonstrated success in teaching introductory geology, whose primary responsibility would be to teach and coordinate Geological Sciences 101, a large lecture/lab course for non-majors. Rank of Lecturer or Assistant Professor depending on research experience and availability of funding. Beginning September 1983.

Position 2. Possible opening for geologist with strong quantitative, theoretical background as well as commitment to field related studies. We are particularly interested in the area of economic geochemistry. Successful candidate would be expected to carry out a rigorous research program as well as to contribute to teaching responsibilities at both the undergraduate and graduate level. Assistant Professor (tenure-track) rank, beginning September 1985.

Position 3. Electron microprobe specialist. This position is supported at the 50% level by the department, and would require the successful applicant to provide up to 50% salary support from research grants or other sources. This is a non-tenured faculty position at the rank of Research Assistant Professor. Candidates should have a record of successful grant-supported research in mineralogy/petrology involving use of the electron microprobe. The position requires supervision and operation of the microprobe facilities, and teaching one course. This position will be available after January 1983.

Applicants should send vita, letter of teaching and research interests, and names of four references to John B. Adams, Chairman, Department of Geological Sciences, AJ-20, University of Washington, Seattle, Washington 98195 by *1 March 1983.*

The University of Washington is an affirmative action/equal opportunity employer.

Physical Oceanography/Memorial University of Newfoundland. Applications are invited for a faculty appointment in physical oceanography which is to be made in the PHYSICS DEPARTMENT for June 1, 1983, subject to final budgetary approval. Rank and salary are negotiable and commensurate with the qualifications of the appointee. Considerable research experience beyond a Ph.D. degree is preferred. The position offers a challenging academic career with stimulating research opportunities focussing in the Northwest Atlantic and the Canadian Arctic. The Department has an active group engaged in field studies of fjords in Newfoundland, Labrador and Baffin Island and the submarine canyons of the Grand Banks, and in the application of a numerical sea-ice model to the Labrador Sea and Baffin Bay. This group interacts closely with other oceanographers, both inside and outside the University, through the Newfoundland Institute for Cold Ocean Science.

Candidates are sought whose primary interests are in theoretical investigations of continental shelf and coastal dynamics but ours is a new and growing program and qualified individuals with experience in any area of physical oceanography should apply. An interest in interdisciplinary research and co-operation would be an asset. The appointment will include teaching duties at the graduate and undergraduate levels. Applications, including curriculum vitae and the names of three referees, or requests for information should be addressed to:

Head, Department of Physics,
Memorial University of Newfoundland,
St. John's, Newfoundland, Canada,
A1B 3X7.
Telephone: (709) 737-8738

In accordance with Canadian Immigration regulations this advertisement is directed to Canadian citizens and landed immigrants in the first instance.

Geophysicist/University of Montana. The Geology Department of the University of Montana is inviting applications to fill a tenure track position at the assistant or associate professor level with a specialized area of geophysics beginning Sept. 1983. Teaching and research responsibilities at the undergraduate and graduate levels. Research interests should combine solid earth geophysics and geology.

Applicant must have the Ph.D. degree or expect completion by summer 1983. Those interested should send a letter of application, resume, an outline of teaching and research interests and other relevant material. The applicants should arrange to have at least three letters of recommendation sent to: Arnold J. Silverman, Chairman, Department of Geology, University of Montana, Missoula, MT 59812.

The deadline for applications is March 15, 1983.

The University of Montana is an affirmative action/equal opportunity employer.

Assistant Professor/SUNY-Plattsburgh. Applications are invited for an anticipated tenure track position at the rank of assistant professor beginning fall 1983. Area of teaching and research interests should be in paleontology, stratigraphy, and paleoecology. Teaching duties will also include a share of introductory geology and environmental science courses. The setting of the college in the Champlain Valley which offers excellent opportunities for research and demonstration in classical Ordovician carbonates. The department is a recently formed Center for Earth and Environmental Science which has responsibility for a satellite campus offering opportunities for student involved research and nontraditional teaching approaches. Address application and 3 letters of reference by March 25, 1983 to: Dr. Donald Adams, Director, Center for Earth and Environmental Science, Box 200, SUNY, Plattsburgh, NY 12901.

An Equal Opportunity/Affirmative Action Employer.

University of Minnesota, Morris/Tenure-Track Academic Position in Geology. The Division of Science and Mathematics invites applications for a tenure-track position in Geology at the Assistant Professor level, beginning September 16, 1983. Applications are invited from all specialties, but preference will be given to those able to teach *Structural Geology* and courses in one of the following areas: *Mineralogy and Petrology; Geophysics and Subsurface Methods;* or *Hydrogeology and Quaternary Geology.* Participation in teaching introductory courses and occasionally the summer field camp program is expected. Previous teaching experience at the college level or closely related experience desired. Ph.D. in hand, or in final stages of completion required. Salary is open and competitive with other academic institutions.

Emphasis will be placed on the ability to teach and work effectively with highly motivated undergraduates; research activities commensurate with a quality undergraduate Liberal Arts Program are required.

The Geology Discipline offers programs leading to BA degrees in Geology as well as in Earth Science Education. There are 50 majors in the discipline, with upper division classes averaging 20–30 students. Excellent classrooms and lab facilities available, with computer access provided in faculty offices and most classrooms.

UMM is a four year public Liberal Arts campus of the University of Minnesota, with an average enrollment of 1760 students, located in rural West Central Minnesota, 150 miles west of Minneapolis/St. Paul.

Interested applicants should send a resume, college transcripts, and three letters of reference to:

Dr. James M. Olson, Chairman
Rm 217B
Science and Mathematics Division
University of Minnesota, Morris
Morris, MN 56267

THE DEADLINE FOR APPLICATION IS APRIL 15, 1983.

The University of Minnesota, Morris is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Faculty Positions/The University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure-track assistant professors or visiting professors of any rank in August 1983. Preference will be given to experimentalists in any area for the tenure-track positions. Current research interests include astronomy, atomic, condensed matter, elementary particle, laser, nuclear, plasma, and space physics. The positions involve undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a résumé and a statement of research interests, and have three letters of recommendation sent to *Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.*

The University of Iowa is an equal opportunity/affirmative action employer.

Faculty Position/Northwestern University. The Department of Geological Sciences is seeking a creative individual whose interests are compatible with the existing research strengths of the Department. These are in the areas of geophysics, tectonics, geochemistry, sedimentary geology, paleoclimatology. While area of specialization is open, candidates should have a strong commitment to graduate instruction and research. An appointment to a tenure track Assistant Professorship is anticipated. Applicants should submit a resume and the names of three referees to:

B. J. Wood
Department of Geological Sciences
Northwestern University
Evanston, IL 60201
312-492-3112.

The closing date is February 18, 1983.

An equal opportunity employer.

Graduate Research Assistantships in Earthquake and Exploration Seismology/University of Kansas. The computer acquisition of digital seismograms for a 20+1 station seismic network covering the southern end of the Central North American Rift System and the development of techniques for Very High Frequency (500–1000 Hz) reflection seismology provide excellent opportunities for graduate study at the M.S. or Ph.D. level. For further information and/or application, please write:

Dr. George H. Rothe, Chairman
Geophysics Program
Department of Geology
University of Kansas
Lawrence, Kansas 66045
(913) 864-4974.

POSITIONS WANTED

Plasma Physics/Applied Physics Theorist & Computer Modeler (Ph.D.). Seeks faculty position. Numerical simulations of plasma-sheath, photosheath, and wake interactions with 3D spacecraft. Generalized Langmuir Probe theory and transport effects, and electron-beam-irradiation of solid dielectrics. Experience: eight years national laboratory; 21 years industrial; visiting scientist at several institutions; approximately 100 publications. Box *013*, American Geophysical Union, 2000 Florida Avenue, NW, Washington, D.C. 20009.

Hydrologist/Hydrogeologist (PhD). Seeks teaching/research position. Over six years' experience with university system. Enthusiastic, versatile teacher and active researcher with strong record of external support. Box 014, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

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Roy Young, Caribou Star Route, Nederland, CO 80466, 303-258-3846.

Meetings

Announcements

AAAS Divisions Meet

The 64th Annual Meeting of Pacific Division of the American Association for the Advancement of Science (AAAS) and the 59th Annual Meeting of the AAAS Southwestern and Rocky Mountain Division will be held jointly at the Utah State University in Logan, June 19–24, 1983.

The American Meteorological Society and Section W (Atmospheric and Hydrospheric Sciences) of the two AAAS divisions will cosponsor paper sessions, a symposium entitled 'Man-Atmosphere Interactions in Arid and Semi-Arid Environments,' and, possibly, other programs. Atmospheric energy, environmental pollution, and the climatology, meteorology, and hydrography of various areas are among the topics expected to be investigated.

Abstracts should be sent by April 1, 1983, to the program chairman, John Lier, Department of Geography and Environmental Studies, California State University, Hayward, CA 94542 (telephone: 415-881-3193). Include with the abstract a list of special equipment (such as overhead, lantern slide, opaque, or 35-mm slide projectors) that would be needed for the presentation. Details on the entire program, abstract format, registration, housing, and transportation can be obtained from Alan E. Leviton, Executive Director, AAAS (Pacific Division), California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118 (telephone: 415-752-1554) or from M. Michelle Balcomb, Executive Officer, AAAS (Southwestern and Rocky Mountain Division), Colorado Mountain College, 3000 Country Road 114, Glenwood Springs, CO 81601 (telephone: 303-945-8165).

Geophysical Year

New Listings

The complete Geophysical Year last appeared in the December 21, 1982, *Eos.*

A boldface meeting title indicates sponsorship or cosponsorship by AGU.

June 18–22, 1983 Fifth International Conference on Finite Elements in Water Resources, Burlington, Vt. (J. P. Laible, Finite Element Conference, Department of Civil Engineering and Mechanical Engineering, University of Vermont, Burlington, VT 05405).

June 19–24, 1983 64th Annual Meeting of the Pacific Division of the American Association for the Advancement of Science (AAAS) and the 59th Annual Meeting of the AAAS Southwestern and Rocky Mountain Division, Logan, Utah. Sponsor, American Association for the Advancement of Science Pacific and Western divisions. (Alan E Leviton, Executive Director, AAAS (Pacific Division), California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118; M. Michelle Balcomb, Executive Officer, AAAS (Southwestern and Rocky Mountain Division), Colorado Mountain College, 3000 Country Road 114, Glenwood Springs, CO 81601.)

February 1984 Ocean Sciences 1984. Sponsor, AGU. (John R. Apel, Assistant Director for Planning, The Johns Hopkins University, Applied Physics Laboratory, Johns Hopkins Road, Laurel, MD 20707.)

May 14–18, 1984 AGU Spring Meeting, Cincinnati, Ohio. (Meetings, AGU, 2000 Florida Avenue, Washington, DC 20009.)

May 27–31, 1985 AGU Spring Meeting, Baltimore, Md. (Meetings, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.)

Changes

Dec. 5–10, 1983 AGU Fall Meeting, extended one extra day.

Meeting Report

Continental Scientific Drilling At Long Valley-Mono Craters*

Deep drilling is an important means of exploring the structure and conditions within continental crust. It is recognized as an important tool in understanding the structure of continental basement rocks, the nature and properties of thermal and volcanic regimes, the amount and character of mineral resources, the causes and consequences of earthquakes, and in testing geophysical interpretations based on surface and near-surface observations [*U.S. Geodynamics Committee,* 1979]. A major basic research program, funded principally by the Department of Energy and the U.S. Geological Survey, is now underway to assess the suitability of the Long Valley-Mono Craters volcanic complex for deep drilling under the auspices of the thermal regimes portion of the Continental Scientific Drilling Program (CSDP). Scientific investigators participating in the site assessment represent several agencies, national laboratories, and universities, as well as the private sector.

Much of the current effort has its origins in a series of unsolicited proposals submitted to the Geosciences Research Program in the Office of Basic Energy Sciences of the U.S. Department of Energy. Proposal of the Long Valley-Mono Craters region as a thermal regimes site for CSDP was based upon the criteria that a location (1) have an active magma/hydrothermal system, (2) be a geophysically definable target, and (3) be exemplary of an important class of systems whose results are generally applicable to other sites. The history of intense silicic volcanism in the region, continuing essentially to the present with both explosive and effusive eruptions as recently as a few hundred years ago (see cover figure), provides ample evidence of an active crustal magma system, the most active rhyolitic system in the conterminous United States. Extensive areas of hot springs, fumaroles, and hydrothermal alteration are the surface expression of a large hydrothermal system beneath Long Valley that has been explored, to some extent, by drilling. More localized systems are likely near the recently active vents of Mono Craters and Mono Lake. Anomalous seismic reflections and waveforms of seismic waves propagating through the region, together with persistent earthquake swarms and ongoing surface deformation coinciding with volcanic structures, suggest the presence of magma at drillable depths beneath Long Valley. The continuation, and indeed greater abundance, of young volcanic features northward into the Mono region raises the possibility that geophysical observations may detect magma beneath this area as well. Conditions are favorable for defining a magmatic target beneath the Mono Craters center because the shallow crustal structure is relatively simple. Finally, individual volcanic centers within the region appear to represent examples of different stages in the development of silicic caldera complexes. Results from drilling would therefore be applicable to other members of this major and important class of igneous systems.

*This work performed at Sandia National Laboratories and supported by the U.S. Department of Energy under contract DE-AC04-76DP00789 for the Office of Basic Energy Sciences.

Regional Setting and Geologic History

Geophysically, the Long Valley-Mono Craters volcanic complex sits directly astride the important boundary between Sierran basement structure and the extensional regime of the Basin and Range. Coinciding with this change in the style of crustal deformation is a dramatic change in the thermal regime [*Lachenbruch et al.,* 1976]. To the west, on the Sierra Nevada escarpment, measured heat flows are typically 50% lower than they are just a few kilometers to the east.

This major boundary within the continental crust has been the locus of intense volcanic activity during Pleistocene and Holocene time. Volcanism in the Long Valley-Mono Craters region [*Bailey et al.,* 1976] began about 3 m.y. ago with widely scattered mafic eruptions, but became more concentrated and more silicic in character 2 m.y. to 1 m.y. ago with the development of the Glass Mountain complex, an accumulation of high silica rhyolite flows and tephra resembling the modern Mono Craters. These small-to-moderate volume explosive and effusive events were followed by the cataclysmic eruption 0.7 m.y. ago of 600 km^3 of rhyolite magma to form the Bishop Tuff, accompanied by 2–3 km of subsidence in the source region to form Long Valley caldera. Caldera collapse occurred in part along an arcuate fracture zone defined by Glass Mountain vents, suggesting a relationship between the Glass Mountain eruptions and the large shallow magma body responsible for the Bishop Tuff eruption. Uplift of the west-central caldera floor to form the resurgent dome and intracaldera eruptions quickly followed caldera collapse, and about 1 km of tephra and tuffaceous lake sediments were deposited. Although the Bishop Tuff is nowhere exposed within the caldera, results from three moderate-depth drill holes, combined with gravity and seismic data, revealed that more than half the total volume of the tuff is contained within this structural depression [*Hildreth,* 1979].

Intracaldera eruptions span most of the time after caldera collapse up to the present; and many of these eruptions vented from the western portion of the ring fracture zone. In general this activity is characterized by declining volume and silica content and increasing crystal content with time. Hildreth has documented chemical zonation within the Bishop Tuff magma, and Bailey et al. have interpreted the post-caldera eruption history as the tapping of successively deeper levels of a large, zoned, inwardly crystallizing pluton.

Within the past few tens of thousands of years, two new volcanic centers have developed immediately to the north of the caldera. These are the predominantly rhyolitic Mono Craters, an arcuate arrangement of huge domes and stubby flows with major associated tephra deposits, and the much smaller and compositionally more diverse Mono Lake group of vents. The arc defined by the Mono Craters vents can be traced through nearly 360° as a zone of mylonitization and faulting, perhaps marking the boundary of the foundering roof of a magma chamber [*Kistler,* 1966]. Within the last thousand years, significant eruptions have occurred at both ends of the Mono Craters chain and possibly in Mono Lake. These eruptions included development of a new chain of vents, represented by the Inyo Domes and Inyo Craters, extending southward from the tip of Mono Craters into western Long Valley caldera. Although these vents overlap the older Long Valley system, their eruption products bear chemical affinity to Mono Craters.

Seismicity along the Sierra Nevada-Basin and Range boundary has also been intense and is responsible for its spectacular topographic expression. During the great Owens Valley earthquake of 1872, the ground surface broke along the Sierran front to within 30 km of Long Valley. Moderate events in the vicinity of Long Valley and Mono Craters occurred in 1889, 1910, 1912, 1927, 1929, 1938, and 1941. The Hilton Creek-Laurel Mountain fault zone immediately to the south of Long Valley was the site of four $M_L \geq 6$ earthquakes from May 25–27, 1980 [*Cramer and Toppozada,* 1980] and has been the site of much activity since (*Ryall and Ryall* [1981]; A. Ryall, personal communication, 1982).

Evidence for Magma

A variety of data indicate that magma probably exists today underneath Long Valley and the Mono Basin. A seismic refraction line run in 1973 detected a suggestive reflection just east of the southern Deadman Creek rhyolite dome, which is the youngest dated vent in the region [*Hill,* 1976]. This reflection was almost identical in waveform to the first part of the wave train but shifted 180° in phase, indicating passage from a high-velocity to a low-velocity horizon. On certain seismic ray paths through the caldera, anomalous *p* and *s* wave attenuation has been observed, possibly indicating a magma chamber at depth [*Ryall and Ryall,* 1981]. Several of the seismic events during 1980, 1981, and 1982 give the appearance of spasmodic tremor usually associated with volcanism (A. Ryall, personal communication, 1982). These swarms appear to be at decreasing depths occurring over the past year and a half, perhaps because magma is intruding progressively nearer the surface. Leveling changes of up to 25 cm [*Savage and Clark,* 1982] and gravity changes of up to 50 μGal (R. Jachens, personal communication, 1982), which spanned roughly the year following the May 1980 earthquake swarm, appear to indicate inflation of the ground surface, possibly because of the injection of magma at depth. These data suggest that the uplift was centered on the resurgent dome and give credence to the hypothesis that magma injection is occurring. Additional support for involvement of magma comes from the location of recent earthquake swarm activity on the southern ring fracture zone of the caldera, nearly on line with the young Inyo vents (A. Ryall, personal communication, 1982).

Mammoth Lakes—May 1982

It was against this background of increasing tectonic, and possibly volcanic, activity that the CSDP site assessment began. The effort was initiated by the Office of Basic Energy Sciences, U.S. Department of Energy, and has so far involved organizing sessions at the 1981 American Geophysical Union Fall Meeting in San Francisco; in Reston, Va., with the U.S. Geological Survey; and an open workshop and field trip held May 3–7, 1982, at Mammoth Lakes, Calif. The meeting at Mammoth Lakes was attended by over 80 scientists from government agencies, national laboratories, universities, and private industry. On May 4 a series of presentations was given by scientists funded under the program who described previous and proposed work. On May 5 a field trip to sites of volcanic and tectonic interest, traversing the entire volcanic field from north to south, concluded the formal activities.

On May 4, presentations began with an overview of project objectives by J. Rundle (Sandia National Laboratories), followed by a historical and national perspective of CSDP by R. Andrews (National Academy of Sciences Continental Scientific Drilling Committee). The sites under consideration for a deep (~10 km) drill hole were discussed along with the relevance to those goals of drilling in the Long Valley-Mono Craters region. D. Kreske (U.S. Forest Service, Inyo National Forest) discussed forest service interest in and activities related to geothermal development in the area. She also summarized permit procedures and ways to increase cooperation between the various investigators and the Forest Service. J. Eichelberger (Sandia National Laboratories) closed the opening remarks by reviewing the geological significance of the area to CSDP.

The scientific session opened with a discussion of heat flow and a comprehensive discussion by A. Lachenbruch (U.S. Geological Survey) on the physical implications of the heat flow measurement at Aeolian Butte (ABT), located near the geometric center of the Mono Craters ring fracture system. Lachenbruch stated that there seems to be no detectable heat flow anomaly at ABT, provided that background heat flow appropriate to the Basin and Range Province is assumed. A magma chamber whose roof was congruent with the ring fracture zone would cause a substantial anomaly (~½ HFU) at ABT if it were closer to the surface than 10 km during the last 0.7–1 m.y., the age of the ring fracture according to Kistler. Using a simple conduction model with a chamber roof at 8 km, emplacement would have to be less than about 300,000 years ago, and at 6 km would have to be less than about 150,000 years ago in order to avoid producing a detectable anomaly. Lachenbruch plans to measure heat flow in several 200-m holes to clarify the transition from Sierran values to Basin and Range. J. Dunn (Sandia National Laboratories) then gave a synopsis of drilling activity planned by Sandia. The drilling program included measurement of heat flow at two geophysically interesting sites as well as drilling several instrumentation test holes. These holes will be bored for the purpose of testing a device currently under development for directly measuring the Nusselt number in regions of convective heat flux.

The next group was concerned with measurements related to crustal deformation and included J. Rundle, J. Whitcomb (University of Colorado), and R. Jachens (U.S. Geological Survey). Jachens began by describing his recent gravity change measurements in the Long Valley Caldera. Most of these were taken near Route 395 between Little Antelope Valley and Paradise Camp from June 1980 to October 1981. The data, which show as much as −54 μGal of change, generally support the leveling data that imply about 25 cm of uplift centered on the resurgent dome [*Savage and Clark,* 1982]. A problem in interpretation, however, is evident from the observation of −33 μGal change at Tom's Place on the southeast boundary of the caldera. Jachens plans to remeasure these stations as well as install some new ones in the Long Valley Caldera.

Whitcomb reviewed his measurements of precise gravity changes in southern California. This project, which is now 6 years old, has been conducted under the auspices of the NASA Geodynamics Program and the USGS Earthquake Prediction Program. With the development and use of a new absolute gravity meter, a tie now exists between the southern California gravity net and absolute gravity measured at four locations in southern California, including Owens Valley Radio Observatory. Whitcomb and Rundle plan to install additional stations in the Long Valley-Mono Craters area to monitor gravity changes and to increase the gravity measurements used for structural gravity interpretation in the area.

Rundle discussed recent methods and techniques he has developed for computing Green's functions in layered media. These techniques utilize a solution to the coupled elastic-gravitational field equations in the form of a Fourier-Bessel solution integral. The source can be placed at arbitrary depth in a plane layered medium, where densities and elastic moduli of each layer can be cho-

sen separately. Rundle plans to continue development of these modeling techniques and to apply them to the interpretation of structural gravity, gravity change, and deformation data at Long Valley-Mono Craters.

Geological and geochemical investigations were the concluding subject of the morning session. J. Eichelberger described plans for chemical characterization of recent eruption products, which must closely represent the current state of magma beneath the region. An important aspect of this investigation will be analysis of volatile components, especially water, in fresh bubble-free glasses from both tephra deposits and domes. Eichelberger summarized results of recent work with H. Westrich indicating that these volatiles are magmatic and are retained in the tephra clasts in preeruption concentrations because of extremely rapid quenching. Water contents as high as 3 wt. % have been observed in obsidian clasts from Cascade tephras, or about an order of magnitude more water than previously reported for fresh, subaerially erupted glasses. Water contents in bubble-free Mono/Inyo glasses will be correlated with other observations, such as mode of eruption, phase assemblage, and major and trace element composition. Comparisons will be made between vesiculated and nonvesiculated samples to investigate chemical transport during degassing. Sampling will be coordinated with tephra studies by C. D. Miller (U.S. Geological Survey), and data from the tephra will supplement petrologic studies of the young domes by R. Bailey (U.S. Geological Survey), as discussed below. Results will be applied to development of a geophysical model for the magma system and to identification of evolutionary trends in the recent magmatic activity.

C. D. Miller presented early results from his work involving tephra studies and volcanic hazard assessment in the Long Valley/Mono Craters area. This investigation began in 1979 but was interrupted by the activity at Mount St. Helens and will resume this summer. Building on earlier tephra studies by *Wood* [1977], Miller has identified a large number of pyroclastic flow and air fall events younger than about 2000 years in the vicinity of the Inyo Domes and southern Mono Craters. The youngest date of 200 radiocarbon years was obtained from a pyroclastic flow underlying the Deadman Creek dome. Miller also described evidence for two previously unknown vents, one on White Wing Mountain and a mantle feature south of Inyo Craters. In terms of volcanic hazards he emphasized the wide range of plausible consequences from renewed activity in view of the wide distribution of recently active vents and the large variations in magma composition, eruption mechanism, and erupted volume.

R. Bailey reviewed results from his extensive work on the geology and petrology of Long Valley Caldera and presented new data from his more recent and ongoing investigation of Mono Craters. He emphasized the high, and apparently increasing, rate of magma extrusion from the Mono Craters system over the past few thousand years and observed that there is a crude age progression from the center of the Mono Craters arc of vents to the most recently active ends of the arc. Remarkable chemical homogeneity within the arc lavas, the suggestion of a ring fracture structure, and petrologic similarity to late precaldera lavas at Long Valley indicate that Mono Craters may be the surface expression of a large crustal magma body in a precaldera stage of evolution. Bailey proposed a conceptual model in which the Long Valley, Mono Craters, and Mono Lake volcanic centers are linked to the same broad region of melting at mantle depths, but with each having a distinct system at crustal depths. In this view the Long Valley system is a mature, shallow, chemically zoned, perhaps largely crystallized magma body, with the Mono Craters being fed by a deeper, newly arrived, and perhaps more homogeneous reservoir in the midcrust. The Mono Lake system does not yet have a well-established crustal reservoir. Bailey concluded with a summary of plans for geologic monitoring of western Long Valley Caldera; he was motivated by the recent leveling results on the resurgent dome.

J. Hermance (Brown University), F. Morrison (University of California at Berkeley and Lawrence Berkeley Laboratory), and N. Goldstein (Lawrence Berkeley Laboratory) began the afternoon session by discussing magnetotelluric (MT) techniques to be used in crustal sounding. Hermance discussed the passive MT method, which he is currently using in the Mono Craters area. His preliminary results indicate no magma reservoir. He plans to increase the area of coverage and would generally like to keep the area under consideration as large as possible. Morrison and Goldstein described active MT techniques they used in Nevada and at the Valles Caldera in New Mexico to obtain conductivity profiles as a function of depth. They discussed the nonuniqueness inherent in the method, specifically the problem that near-surface very high conductivity layers, such as hot saline water, can mask a signal corresponding to high-conductivity magma at depth. Additionally, they mentioned the highly three-dimensional nature of the measurements and the difficulties involved in interpreting plane-layer models. Morrison and Goldstein plan to try their methods in the Mono Craters area and believe they can detect magma if it exists at shallow depth because of the lack of an extensive hydrothermal system there.

The remainder of the afternoon was devoted to a discussion of seismic methods. D. Hill, W. Mooney, and G. Fuis (U.S. Geological Survey) outlined the seismic refraction techniques they will use. About 100 vertical-component, three-gain-level analog recorders will be employed for some 18 borehole shots of varying strength. The recording arrays will at first probably be laid out with a roughly north-south line along Route 395 from Mono Lake down to Tom's Place and an east-west line from Walker Lake to Mono Mills. This arrangement will allow both structural determination within the Mono Craters ring fracture zone and clarification of the reflector at 7-km depth in the vicinity of Deadman Creek. Analysis methods will employ two-dimensional ray-tracing methods in routine use at the USGS. These methods involve two-dimensional gradients as well as irregular layer structure. To a large extent, plans for summer 1983 will depend on results obtained during summer 1982.

K. McNally (University of California at Santa Cruz) began by reviewing the historic seismicity in the area and discussed the need for accurate locations and focal mechanisms from local events. She also briefly outlined the other tasks of her proposal group, which include collection and modeling of broad-band teleseismic waveforms, statistical studies of local seismicity, waveform modeling of local data, and tectonic modeling and syntheses.

A. Ryall (University of Nevada) presented seismicity patterns in the area derived from data collected on the Reno regional network. Seismicity prior to the May 1980 earthquake sequences shows temporal variations suggestive of activity precursory to strong earthquakes. In general, activity decreased from October 1977 to September 1978, followed by bursts of activity. A magnitude 5.7 shock 25 km northwest of Bishop occurred on October 4, 1978, followed by the May 1980 activity. F. Ryall and A. Ryall have recently discovered a location on the southwest caldera rim from which spasmodic tremor is evidently originating. They noted that this may signal the onset of magma migration to shallow depths. Ryall plans to continue monitoring both in the Long Valley area and in the Adobe Hills region to the northeast, where other anomalous seismicity has occurred. He also plans teleseismic *p* delay studies to assess the possible presence of magma within the Mono Basin and Adobe Hills.

L. Burdick (Woodward-Clyde Consultants) discussed various waveform modeling techniques planned for use with the broadband teleseismic data, regional aftershock data, and NTS nuclear shot arrivals. For the most part these techniques are ray codes developed at Caltech and Woodward-Clyde for synthetic waveform modeling. By the additional use of finite element codes as well as [illegible] techniques, laterally heterogeneous structures can be modeled in addition to plane-layered structures. Specifically, these techniques will be used to search for *s,s* phases reflected off the top of a magma chamber and also to examine regional P_n phases propagating across suspect areas. These efforts will be the primary responsibility of Burdick, D. Helmberger (Caltech), and T. Wallace (Caltech).

Finally, H. M. Iyer and D. Stauber (U.S. Geological Survey) described the *p* delay techniques they plan to use in studying structure beneath the Mono Craters ring fracture. These techniques have been used by Iyer and co-workers on data collected in Long Valley, Yellowstone, the Geysers, Roosevelt Hot Springs, and a number of other areas. They interpret *p* delays by use of an Aki-type model in which the crust is divided up into a series of three-dimensional blocks, each with its own velocities. Stauber described some problems with three-dimensional ray tracing codes of this type which necessitate the use of scaled down variables in the solution matrix. One problem, brought out by floor discussion, is the neglect of changing ray paths in the inversion as block velocities are varied. It was suggested that the neglect of refraction-induced travel time changes might be the root cause for the need of scaled block velocities.

Scientific leadership for the field trip on the following day was provided principally by R. A. Bailey and C. D. Miller, with additional presentations by C. Cramer (California Division of Mines and Geology), J. Eichelberger, A. Lachenbruch, A. Ryall, and K. Sieh (California Institute of Technology). The emphasis of the trip was on geologically and historically new features of the area: young vents, the actively deforming resurgent dome, and new fumarolic activity. On Thursday the meeting divided into groups for discussion of field problems related to specific investigations, such as gravity, seismic refraction studies, and heat flow. Before many of the participants had departed, Mammoth Lakes was shaken by another earthquake swarm, again centered at shallow depth in the southern part of the ring fracture zone. It is anticipated that with continued cooperation and exchange of ideas of the sort in evidence at the meeting, an evaluation of the area as a site for deep scientific drilling will be accomplished within 3 years.

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This meeting report was prepared by J. B. Rundle *and* J. G. Eichelberger *of Sandia National Laboratories, Albuquerque, N. Mex.*

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Dawn J. Wright

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In recognition of the strong support and substantial contribution given by the American Geophysical Union to the American Geological Institute's Minority Participation Program, 16 of the 1982–83 scholarship recipients were designated 'AGU Scholars.' Because of a matching grant from the National Oceanographic and Atmospheric Administration to increase the number of minority students studying in fields related to the development of marine and coastal resources, five of this group were designated 'AGU Sea Grant Scholars.' The AGU Scholars, all of whom are following courses of study related to AGU's broad areas of interest, are Torin J. Edwards, a student of geophysics at the University of New Orleans; Gwendolyn Holler, geophysics, Virginia State University; Jolecia Mitchell, environmental sciences, Howard University; Louis F. Montiel, geohydrology, Northern Arizona University; Alex M. Richards, geophysics, Northern Arizona University; Roxanne G. Rogers, geophysics, Colorado School of Mines; John F. Vargas, geophysics, University of Kansas; Toni M. VanDam, geophysics, University of Colorado; Edith G. Williams, geophysics, Stanford University; Saundra F. Willie, geosciences, California State University, Northridge; and Lacy B. Ward, geophysics, Virginia State University.

The AGU Sea Scholars are Mary-Ann Eames-Ramirez, a student of marine geology at the University of Southern California; Michael W. Howell, oceanography, University of Michigan; Darryl J. Keith, oceanography, University of Rhode Island; Gene A. Norman, oceanography, University of Maryland; and Dawn J. Wright, oceanography, Wheaton College.

Eames-Ramirez, Keith, Norman, and Wright have been AGU Scholars in prior years.

Travel Grants to IUGG General Assembly

Deadline for applications: January 31, 1983

AGU has applied to the National Science Foundation for a grant to assist the travel of individual U.S. scientists to the 18th General Assembly of the IUGG to be held in Hamburg, Federal Republic of Germany, August 15–27, 1983. In anticipation of favorable action by NSF, application forms for individual grants are available from:

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009
(Telephone: 202/462-6903
or toll free: 800/424-2488)

AGU Congressional Science Fellowship

The individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science and be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $27,000, plus travel allowance.

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details, write or call Member Programs Division, Congressional Fellowship Program, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009. (telephone: 462-6903 or 800-424-2488 outside the Washington, D.C. area).

Deadline: March 31, 1983

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Solar Physics, Astrophysics, and Astronomy

7710 Corona
Slow Shocks Around the Sun
Y. C. Whang (Department of Mechanical Engineering, Catholic University of America, Washington, D. C. 20064)
It is inferred from this study that magnetohydrodynamic slow shocks can exist in the vicinity of the sun. The study uses a two-hole corona model, the sub-Alfvenic streams originating from the edge of the polar open-field regions are forced to turn towards equator in coronal space following the curved boundary of the closed field region. When the streamlines from the opposite poles merge at a neutral point, their directions become parallel to the neutral sheet. An oblique slow shock can develop near or at the neutral point, the shock extends polewards to form a surface of discontinuity around the sun. (Corona, magnetohydrodynamic slow shock).
Geophys. Res. Lett., Paper 2L1307

7720 Electromagnetic Radiation
A THREE-COMPONENT MODEL OF THE VARIABILITY OF THE SOLAR ULTRAVIOLET FLUX: 145-200 NM.
J. L. Lean (Cooperative Institute for Research in Environmental Sciences, CIRES, University of Colorado/NOAA, Boulder, Colorado, 80309), O. R. White, W. C. Livingston, D. F. Heath, R. F. Donnelly and A. Skumanich.
A three-component model has been developed to examine the variation with solar activity of the far ultraviolet irradiance between 145 and 200 nm. This model is based on spatially resolved observations of the Ca II K chromosphere and includes the contributions to the full disc flux from both plage and active-network emission. The 27 day modulation of the ultraviolet flux is explained by the evolution and rotation of the plage regions on the solar disk. Over the longer time scale of the eleven year cycle it is essential that changes in the active-network arising from the decay of plage regions also be considered as a source of ultraviolet flux variability. Only by using a three component model of the solar flux is it possible to simultaneously reproduce the 27 day variability observed by the Solar Backscatter Ultraviolet Experiment on the Nimbus 7 satellite and the changes from the minimum to the maximum of the solar activity cycle observed by the rocket experiments of the Laboratory for Atmospheric and Space Physics and by the Extreme Ultraviolet Spectrometer on the Atmospheric Explorer-E satellite. It is shown that the AE-E experiment measured a smaller solar cycle variability for the ultraviolet irradiances than is predicted by the model calculations because of the spatially restricted field of view of this instrument.
J. Geophys. Res., Blue, Paper 2A1488

7720 Electromagnetic Radiation
DETAILED OBSERVATIONS OF THE SOURCE OF TERRESTRIAL NARROWBAND ELECTROMAGNETIC RADIATION
A. O. Kurth (Dept. of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242)
We present detailed observations of a region near the terrestrial plasmapause where narrowband electromagnetic radiation (previously called escaping nonthermal continuum radiation) is being generated. These observations show a direct correspondence between the narrowband radio emissions and electron cyclotron harmonic waves near the upper hybrid resonance frequency. In addition, electromagnetic radiation propagating in the Z-mode is observed in the source region which provides an extremely accurate determination of the electron plasma frequency and, hence, density profile of the source region. The data strongly suggest the electrostatic waves and not Cerenkov radiation are the source of the banded radio emissions and define the coupling which must be described by any viable theory. (Narrowband electromagnetic radiation, Z-mode, Upper hybrid resonance bands).
Geophys. Res. Lett., Paper 2L1678

7720 Electromagnetic Radiation
ACTIVE-REGION EVOLUTION AND SOLAR ROTATION VARIATIONS IN SOLAR UV IRRADIANCE, TOTAL SOLAR IRRADIANCE AND SOFT X-RAYS
R. F. Donnelly (Space Environment Laboratory, NOAA/ERL, Boulder, Colorado 80303), D. F. Heath and J. L. Lean
Variations in the solar UV spectral irradiance, the total solar irradiance, and solar soft X-ray emission over days and weeks are analyzed using concurrent measurements from the NIMBUS-7 and GOES satellites. The UV variations at wavelengths (160-400 nm) of interest to ozone photochemistry and the physics of the middle atmosphere are emphasized. The nonflare variations studied are caused by two types of processes: (1) the birth, growth, peak, and decay of solar active regions and (2) solar-rotation, for example when portions of active regions are occulted near the solar limb. The observations are interpreted using simple empirical models that relate ground-based observations of the size and location of sunspots and plages to the full-disk temporal variations. The major dips observed in the total solar irradiance on August 20-23 and November 6-10, 1979, and April 8, May 25, and September 1, 1980, are accompanied by only average UV and X-ray enhancements. The models show that the active regions associated with the sunspots responsible for the major dips in the total solar irradiance caused strong but not outstanding emission enhancements at UV and X-ray wavelengths. The solar-rotation variations are studied as a function of the central meridian distance (CMD) of solar regions where the CMD width at half the maximum is narrowest for decreases in the total solar irradiance (~63°), slightly wider, and also a function of wavelength for UV enhancements (~95° at 198 nm), wider still for the 10.7 cm radio flux (~150°), and extremely wide for soft X-rays (≳ 205°). (Solar, ultraviolet, total solar irradiance, X-rays, plages, sunspots, active regions, solar rotation).
J. Geophys. Res., Blue, Paper 2A1402

7760 Radio Astronomy
A PHASE-COHERENT LINK VIA SYNCHRONOUS SATELLITE DEVELOPED FOR VERY LONG BASELINE RADIO INTERFEROMETRY
S. H. Knowles (E. O. Hulburt Center for Space Research, Naval Research Laboratory, Code 4132, Washington, D. C. 20375), W. B. Waltman, J. L. Yen, J. Galt, D. N. Fort, W. H. Cannon, D. Davidson, W. Petrachenko, and J. Popelar
A high-precision phase-coherent link between remote interferometer stations has been developed, and has been utilized in a transcontinental radio interferometer to assess the feasibility of improved astrometric and geodetic measurements. A dual-tone transmission method effectively cancels most phase-degrading effects. An experimental Allan variance curve indicates that stability of 1×10^{-13} was achieved over a one-hour period; the slope of the Allan variance curve was close to -1 for all time intervals up to 20 hours, indicating that the link is truly phase-stable at frequencies of less than 1 GHz. Changes in the link path were measured with an accuracy of 350 picoseconds, corresponding to 10 cm, over periods of several hours. (Satellite link, frequency standards).
Rad. Sci., Paper 2S1066

7760 Radio astronomy
FORMATION OF JOVIAN DECAMETRIC S-BURSTS BY MODULATED ELECTRON STREAMS
D. H. Staelin (Room 26-341, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139) and P. W. Rosenkranz
Jovian S-bursts that are V shaped in the frequency-time domain have been reported by several observers. These can arise if an outward-moving ~2.5 Kev electron beam in the Io flux tube is longitudinally modulated in velocity by ~1 Kev peak-to-peak, at a frequency of several Hertz. Such modulation near the ionosphere could also explain the difference between the maximum observed frequencies of S-burst and L-burst emission. In order for this beam to produce the observed total S-burst flux, a large part of the $\sim 5 \times 10^6$ A current observed in the Io flux tube must participate. In this case the observed duration of individual S-bursts is consistent with magnetospheric ion densities greater than ~ 15 cm^{-3}. This ballistic model for S-bursts also suggests an interpretation for the origin of L-burst emission. (Jupiter, S-bursts, radio emission, modulated electron beams).
J. Geophys. Res., Blue, Paper 2A1407

7770 Sunspots
SUNSPOT TIME SERIES: SPECTRUM FROM SQUARE LAW MODULATION OF THE HALE CYCLE
C.P. Sonett (Department of Planetary Sciences, Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721)
Maximum entropy (MEM) analysis of the sunspot time sequence as autoregressive (AR) order 100 for the past two hundred years discloses 10 spectral lines in the period interval between 90 years and about 8 years. These lines are consistent with a synthetic time sequence consisting of the 22 year Hale cycle viewed as a carrier which is amplitude modulated by the 90 year Gleissberg period. The square of this time sequence yields the 90, 45 and 11 year periods with the latter actually consisting of a quintet of lines, the satellites separated from 11 years by integral multiples of 90 years. The addition of a small offset from zero mean of the 22 year "carrier" additionally yields a quintet centered about 22 years with satellites again separated from the central line by multiples of 90 years. Two sets of lines actually overlie one another finally yielding 10 lines, consistent with the spectrum of the actual time sequence. This model places the Hale cycle as "master clock", it explains the 45 year line and the 11 year quintet as artifacts of the squaring operation, consistent with the sunspot sequence being positive definite, and, because of the "carrier" offset, a solar core field is suggested. Lastly, Gilliland (1981) notes a 76 ± 8 yr radial eigenmode in the Sun, suggesting an as yet unassessed connection to the actual Gleissberg modulation.
Gilliland, Solar radius variations over the past 265 years, Ap.J., 248, 1144 (1981).
Geophys. Res. Lett., Paper 2L1782

7799 General (Solar Irradiance)
SOLAR IRRADIANCE VARIATIONS: 1. ANALYSIS OF MODELLING TECHNIQUES AND INTERCOMPARISON OF GROUND-BASED DATA
L. Oster (Laboratory for Planetary Atmospheres, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771)
We compute the full-disc irradiance at 2800 MHz ("F10.7") on the basis of individual active regions (ARs) on the sun as observed in the light of the Ca II K-line at 393 nm. The solar radio emission is used as a stand-in for UV measurements from above the atmosphere, since it does not have significant calibration problems, and since day-by-day records are available for many years. We illustrate in detail the technique for parameterization of the model calculations which, with few changes, are applicable to UV measurements. In addition to the excellent overall agreement and the impressively close correspondence of day-to-day variations, we find an indication of a systematic discrepancy between model and observations over the entire 10-year period. Nor do we find a contribution to the 2800 MHz irradiance that is not directly correlated to individual ARs on the sun at any given day. We believe that our analysis, by comparison with previous work, is much more detailed without being much more complex, and that it offers a serious chance for an independent estimation of short-term as well as long-term fluctuations of the solar observed irradiance. (Solar irradiance, plages, F10.7).
J. Geophys. Res., Blue, Paper 2A1871